WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

IN-DEPTH CATHODIC PROTECTION SYSTEM INSPECTION AND RECOMMENDATIONS

MAY 2004

LACEY V. MURROW BRIDGE (90/25S)
HOMER HADLEY BRIDGE (90/25N)

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REGISTERED
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INTRODUCTION

Two floating structures, the Homer Hadley Bridge (Bridge No. 90/25N) and the Lacey V. Murrow Bridge (Bridge No. 90/25S) carry Interstate I-90 between Seattle and Mercer Island. The Homer Hadley (HH) Bridge is the larger of the two structures and is located north of Lacey V. Murrow (LVM) Bridge, and carries three lanes of westbound traffic towards Seattle. It also has two reversible express lanes which carry traffic in both directions depending on the time of the day. The LVM Bridge carries three lanes of eastbound traffic towards Mercer Island. The HH Bridge was completed in 1989 and is comprised of 18 floating concrete pontoons and the LVM Bridge was completed in 1993 and is comprised of 20 floating concrete pontoons. Steel cables anchor the pontoons in place. An impressed current cathodic protection system is installed on each cable to prevent corrosion and increase its service life.

An in-depth inspection of all cathodic protection systems was conducted between May 2 and May 19, 2004. This report documents the findings of the inspection and provides recommendations for effective implementation of cathodic protection technology.

EXECUTIVE SUMMARY

Both the HH and the LVM bridges are comprised of floating concrete pontoons. The pontoons are anchored in place by steel cables. An impressed current cathodic protection system is installed on each cable to prevent premature failure due to corrosion. All cathodic protection systems are collectively designated as "the Cathodic Protection System," and each individual system on each cable is designated as a cathodic protection zone. Each cathodic protection zone is comprised of a rectifier and an anode assembly. The rectifier provides DC current to the platinum-niobium anode through appropriate wiring.

A visual inspection of all components of the Cathodic Protection System was conducted. Each anode assembly was pulled out and visually observed and its length estimated and documented. Standard system operating parameters were measured and depolarization and polarization testing were performed.

Visual survey of all anodes of the HH Bridge indicated that 31% of the anodes have failed at or in the endcap (contains mechanical connection between the copper wire and the anode wire) and need to be replaced. The associated cables are presently not protected. The construction quality of the endcaps is not adequate and may have resulted in such a high frequency of failure. In addition, almost all anodes exhibit some level of anode degradation adjacent to the endcaps. Varying lengths of anode wire adjacent to the endcap exhibit complete consumption of platinum coating. In fresh water application, two different criteria are used to ascertain the level of protection provided by a cathodic protection system. The criterion most commonly used requires the polarized potential of the cable to be more negative than -0.800 V with respect to a silver-silver chloride reference electrode for complete protection. The second criterion requires a shift of 0.300 V in the potential of the cable upon application of cathodic protection. The -0.800 V criterion was met by 58% and 81% of the zones of HH Bridge during depolarization and polarization testing, respectively. The 0.300 V shift criterion was satisfied by 38% and 69% of the zones during depolarization and polarization testing, respectively. This level of protection is considered to be inadequate to completely protect the cables from premature failure due to corrosion.

The condition of the newer LVM Bridge cathodic protection system was somewhat better. The failure frequency of the anodes in this bridge was 9%. Also, the -800 mV criterion was met by 82% and 88% of the zones during depolarization and polarization testing, respectively. However, the 0.300 V shift requirement was only met by 4% and 2% of the zones during depolarization and polarization testing, respectively.

Review of the underwater inspection report dated July 2002 suggests that corrosion on certain sections of the cables is ongoing. Corrosion is more severe on the HH Bridge cables and seems to be more concentrated near the pontoon ports, 15 to 20 feet above the top of the submerged anodes. Corrosion on the cables of the LVM Bridge is ongoing, however somewhat slower than the HH Bridge and is noticeable near the pontoon ports on the longitudinal cables. The higher level of corrosion near pontoon ports and higher consumption of the anode material at the top few inches of the anode wire suggest that a higher current demand produced by the corrosion near the pontoon ports concentrated a higher level of current density on the top few inches of the anode wire, thereby, resulting in faster consumption of the anode in the top few inches.

The results of this inspection and the earlier underwater inspection suggest that a more aggressive maintenance and monitoring program is required. Replacement of the missing or damaged anodes and non-operational rectifiers should be a high priority and should be competed within the next 12 months. In addition, the length of the ropes holding up the anodes should be adjusted to raise the top of the anode wire to just below the bottom of the pontoon. Due to the low efficiency at which the system is operating a follow up inspection is recommended immediately after the completion of the anode and rectifier maintenance. A system monitoring and control plan is not in place and it is recommended that one be developed and implemented within the next year. This would provide the necessary guidance to the maintenance crew. At present the maintenance crew has no guidelines to operate and maintain the system. The platinum-niobium anode is not particularly suited for this application; an upgrade to the titanium based anode in the next 5 years is recommended.

DESCRIPTION OF THE CATHODIC PROTECTION SYSTEM

Two floating structures, the Homer Hadley Bridge (Bridge No. 90/25N) and the Lacey V. Murrow Bridge (Bridge No. 90/25S) carry Interstate I-90 between Seattle and Mercer Island. The Homer Hadley (HH) Bridge is the larger of the two structures and is located north of Lacey V. Murrow (LVM) Bridge, and carries three lanes of westbound traffic towards Seattle. It also has two reversible express lanes which carry traffic in both directions depending on the time of the day. The LVM bridge carries three lanes of eastbond traffic towards Mercer Island.

The HH Bridge was completed in 1989 and is comprised of 18 floating concrete pontoons designated as Pontoon A at the Seattle end of the bridge to Pontoon R located at the Mercer Island end. The Pontoons are anchored to the lake floor with steel cables which maintain the alignment of the structure. The end pontoons, A and R, are aligned in the north-south direction and are anchored with four cables each, two on the north end and two on the south end of the pontoons. Pontoons B to Q are aligned in the east-west direction and are anchored in place by two perpendicular cables one on the north side and one on the south side, except Pontoon J. In addition to having the north and the south cables, Pontoon J has 12 longitudinal cables, six of which are located on the north side and six on the south side. The layout of the pontoons and the cables is presented in Figure A-1 in Appendix A.

The LVM Bridge was completed in 1993 and is comprised of 20 floating concrete pontoons designated as Pontoons A to T from Seattle to Mercer Island (west to east). The makeup of LVM bridge is very similar to the HH with Pontoons A and T aligned in the north-south directions anchored with four cables each and the rest of the pontoons aligned in the east-west direction anchored in place by two cables with the exception of Pontoon F and G. Pontoon F has 8 longitudinal cables and Pontoon G has 4 longitudinal cables.

The cable assembly on each pontoon is comprised of the anchor, the steel cable, and the tensioning assembly. The portions of the cables submerged in water are protected by an impressed current cathodic protection system. Each cable is protected by an independent cathodic protection zone comprising of a rectifier and a platinum-niobium anode. The anode assembly is comprised of a rope to lower the anode, copper wire to supply the impressed current, the anode, and termination cap. The connection between the copper wire and the anode is made in the endcap. The anode assemblies are also submerged in water adjacent to the cable to be protected and the length of the platinum-niobium anode varies from one system to another. The anode assemblies are positioned such that the top of the anode wire is approximately 15 to 20 feet below the bottom of the pontoon. The rectifiers are located inside the associated pontoon close to the subject cables tensioning assembly. There are a total of 52 impressed current cathodic protection zones on the HH Bridge and 56 zones on the LVM Bridge.

TESTING PERFORMED

An in-depth inspection of the impressed current cathodic protection system was performed between May 2-19, 2004 by CONCORR, Inc. and Hardesty and Hanover personnel. Washington State Department of Transportation Maintenance personnel assisted in the inspections by providing boats and vehicles to access the required locations, access to the anodes and the rectifiers, and assisted in the inspection. They also provided relevant information pertaining to the maintenance and operation of the systems.

VISUAL SURVEY

A visual survey of the rectifiers and the anodes was conducted. Each anode cable was retrieved from the lake and its condition was visually observed and documented. In addition the overall length of the anode was estimated. The length of each anode was estimated by measuring the diameter of the circle and counting the number of loops produced when the anode was coiled into a circular hoop (see Figure A-2 in Appendix A).

SYSTEM OPERATION PARAMETERS

All system operation parameters were measured for each impressed current cathodic protection system and included, true root mean square (TRMS) system current, TRMS system voltage, anode "on" and "off" potentials, and cable "on" and "off" potentials. The accuracy of the rectifier panel instruments was also verified. The "on" potential is the TRMS potential and "off" potential is IR-drop free potential.

The system current and voltage were read from the rectifier panel meters. These measurements were verified by measuring system current as a voltage drop across the shunt provided in each rectifier and measuring the system voltage across the output terminals. The value from the shunts varied from one make of rectifier to another make.

The anode and cable potentials were measured using a portable silver-silver chloride reference cell designed for use in a marine environment. The reference cell was submerged in the water and it was connected to the negative terminal of the multimeter. The positive terminal of the multimeter was connected to either the positive (i.e. anode) or the negative (i.e. cable) terminal of the rectifier (see Figure A-3 in Appendix A). The "on" potential was measured as the TRMS value of the voltage across the reference cell and the cable or the anode. The "off" potential was measured when the rectifier current output went to zero. As the rectifier output is not filtered, the "off" potential of the anode and anchor cables can be obtained by measuring the minimum and maximum peak of the waveform, respectively. The peaks of the waveforms can be measured by using the min-max function of the multimeter.

One of the challenges that had to be overcome during the inspection was to submerge the reference cell in the water and simultaneously connect to the cable or the anode wire in the rectifier. On the LVM Bridge, this was accomplished by dropping the reference cell in the water adjacent to the access hatch located on the north side and routing the reference cell cable to the rectifier through the hatch. On the HH Bridge the reference cell had to be routed through the cable port in each pontoon to the outside and then dropped in water.

DEPOLARIZATION/POLARIZATION TESTING

After system operation parameters including instant-off potentials of the anode and the steel cables were measured, all rectifiers were powered down and the systems were allowed to depolarize for several days. Subsequent to four (4) days of depolarization, static potential of the cables and the anodes were measured. During measurement of static potentials it was realized that a few of the rectifiers had not been powered down and for those systems, the static potentials could not be measured. Subsequent to that the rectifiers were powered up and the systems were allowed to stabilize for three (3) days prior to measuring operating parameters and instant-off potentials for polarization testing.

TEST FINDINGS

VISUAL SURVEY

All cathodic protection components, especially the anodes were visually inspected. Each and every anode was pulled out of the water, visually inspected and its length estimated. Photographic documentation of typical deterioration was made.

Homer Hadley Bridge

There are a total of 52 rectifiers and 52 anodes installed on this bridge. At the start of the inspection 12 out of the 52 rectifiers were powered down due to missing or damaged anodes. During inspection, two additional anodes were observed to be missing; however the rectifiers feeding power to these anodes were on. While conducting the evaluation two more anodes failed when they were pulled out of the water for inspection and had to be removed. At the end of the inspection, 36 of the 52 zones or 69% of the zones were functional.

The detailed results of the visual survey are presented in Table B-1 in Appendix B. Almost every anode exhibited some form of degradation or failure. Accelerated consumption of platinum at the top of the anode, just below the endcap was prevalent (see Figure A-4 of the Appendix A). This is attributed to excessive current density at this location. Similar damage was also observed at the bottom of the anodes. The anode of Zone JL6N had failed at an intermediate length. The cause of failure was not investigated. The condition of many of the endcaps was not satisfactory. Some had started to deteriorate and water was penetrating inside the caps. In some endcaps the mechanical crimp is extending outside the endcap and water can easily penetrate inside it (see Figure A-5 of Appendix A). In general, the quality of the endcaps is considered to be poor considering the environment it is to be used in. Water penetration inside the caps can result in failure of the connection due to corrosion of the copper in the crimps. The length of the cables varied from one anode to another. It is not known if the varying lengths of the anodes were intentional to meet the current density requirements or they were the result of poor workmanship. Considering that the length of the cables vary due to depth of water, the length of the anodes may have been varied to keep the output current density of the anode under its rated capacity.

The accelerated consumption of platinum coating on the anodes on the top few inches is believed to have resulted due to improper placement of the anodes in the water. The tops of the anodes are located some 15 to 20 feet below the pontoon port. The visual inspection of the cables conducted in July 2002 suggests that the majority of the corrosion on the cables is occurring on the section of the cables near the pontoon port. This may be resulting from higher oxygen availability in the top layers of water in the lake. Therefore, a higher current density demand on the top few inches of the cable is expected and that can lead to accelerated consumption of the platinum coating.

Lacey V. Murrow

There are a total of 56 rectifiers and 64 anodes. Several zones have two anodes instead of one. At the start of the inspection a total of 5 rectifiers were powered down due to failed anodes. At the end of the inspection a total of 50 zones were operational.

The detailed results of the visual survey are presented in Table B-2 of the Appendix. The condition of the anodes was generally much better than that of the Homer Hadley Bridge. Failure of anodes was generally occurring at intermediate lengths suggesting a different mode of failure than the HH Bridge.

DEPOLARIZATION/POLARIZATION TESTING

Many practitioners use polarization (i.e. change in its potential resulting from cathodic protection) of the protected element, the cables for determining the adequacy of the cathodic protection system. The shift in potential is dependent on many variables including the environment. A shift of 0.300 V is considered to be adequate for most environments. In fresh water the -0.800 V criterion is considered to be more relevant and a more stringent criterion. This criterion requires that the polarized potential of the cable be lower than -0.800 V with respect to silver-silver chloride reference cell.

Homer Hadley Bridge

Of the 52 cathodic protection zones on the HH Bridge, twelve (12) zones were not powered due to missing anodes, in two (2) additional zones anodes were observed to be missing during the inspection, and in two zones, anodes broke during visual inspection. One zone was inadvertently not powered down during initial data collection and depolarization/polarization data could not be collected. Therefore, depolarization testing was performed on a total of 37 zones and polarization testing was performed on a total of 35 zones. A summary of the test data presented in Table B-3 of Appendix B indicates that only 38% and 69% of the zones met the 300 mV criteria during depolarization and polarization testing respectively and 58% and 81% met the -0.800 V criterion during depolarization and polarization testing respectively. The average depolarization was

0.258 V and the average polarization was 0.411 V. These numbers indicate that the system is not running optimally to provide complete protection for all of the cables. This confirms the lack of complete protection. The systems will need to be adjusted to provide a higher level of protection. Detailed test data is presented in Tables B-4 and B-5 of Appendix B.

Lacey V. Murrow

Of the 56 zones, 5 were powered down at the start of the inspection. One of the systems had one functional anode and therefore was reenergized during the inspection and polarization testing was performed. During inspection 3 zones were inadvertently left on and no depolarization or polarization data could be collected and 2 zones were inadvertently left off and no polarization data could be collected. Therefore, depolarization testing was conducted on 48 zones and polarization testing was conducted on 47 zones.

The summary in Table B-6 of Appendix B indicates that a very small percentage, 4% and 2% of the zones met the 0.300 V criteria during depolarization and polarization testing respectively. However, the -0.800 V criteria were met by 82% and 88% of the zones during depolarization and polarization testing, respectively. The average depolarization was 0.102 V and the average polarization was 0.158 V. The shift in polarized potentials is somewhat on the lower side. Detailed test data is presented in Tables B-7 and B-8 of Appendix B.

The results of the underwater inspection conducted in July 2002 are explainable considering the performance of the cathodic protection system. Corrosion had slightly increased since the last inspection and the longitudinal cables were exhibiting more corrosion near the pontoon ports than the other cables.

Two rectifiers were observed to be malfunctioning, rectifier of Zone DS had a faulty breaker circuit and that of Zone LS had a malfunctioning rectifier module.

CONCLUSIONS

Homer Hadley

In general the cathodic protection system is not providing adequate protection to the cables. The design of the system may have a role to play in the inadequate protection near the pontoon ports and the level of anode failures observed. A change in anode type, placement, and the design and construction of the endcaps may alleviate the problem. Improved maintenance and monitoring will be required to obtain better protection.

Lacey V. Murrow

The magnitude of corrosion documented by the underwater inspection is lower in this system and the frequency of anode failure is also lower. However, it should be recognized that it is a newer structure and a newer system than the other HH Bridge.

Comparatively, the shift in polarized potential is also lower in this bridge and if the system is operated at the same level, some degree of corrosion on the cables can be expected. Improved maintenance and monitoring of the system will be required to obtain complete protection of the cables.

RECOMMENDATIONS

The recommendations are subdivided into maintenance and rehabilitation requirements.

MAINTENANCE

It is recommended that the following actions be taken:

1. Adjust the length of the rope holding each anode to raise the top of the anode wire to just below the pontoon bottom.

2. Replace all missing and damaged anodes within the next 12 months with alternate titanium anode design provided in Appendix C.

3. Repair or replace the following rectifiers:

    a. Zone DS of LVM Bridge

    b. Zone LS of LVM Bridge

BRIDGE PRESERVATION OFFICE FOLLOW UP

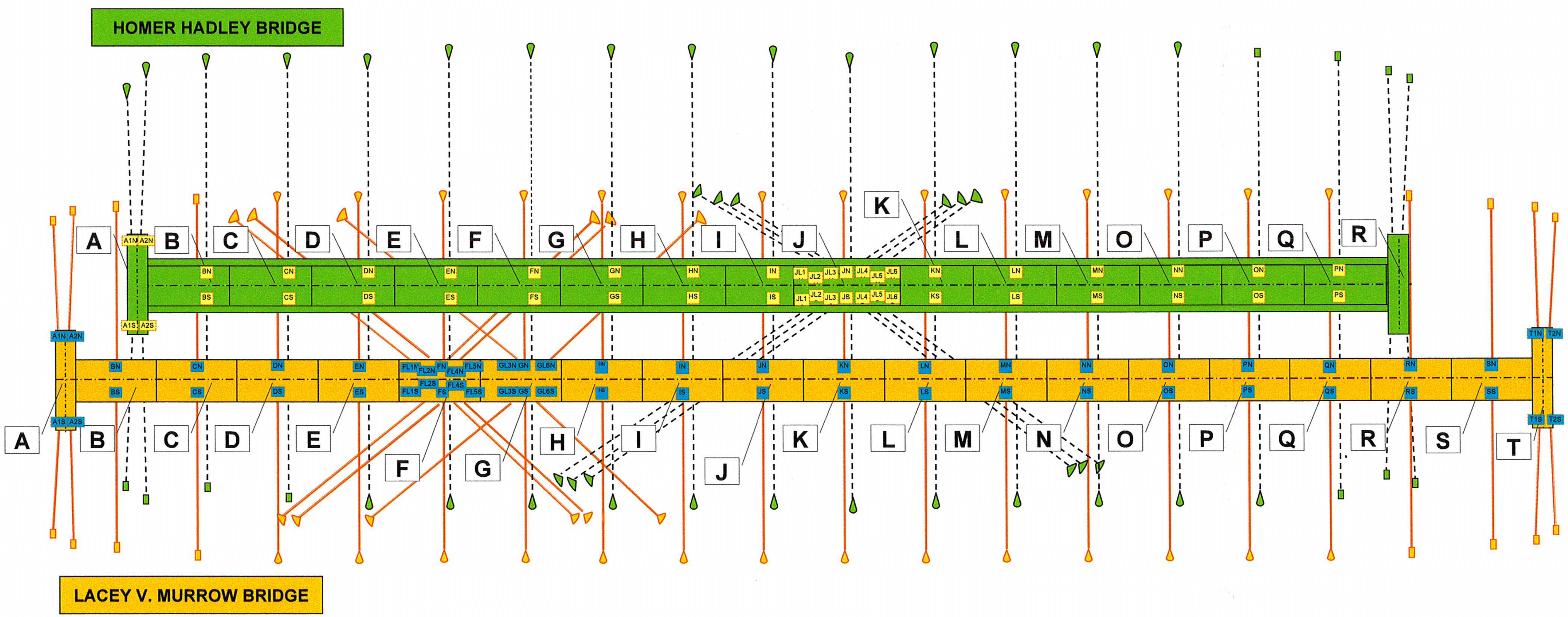
1. Perform a follow up inspection within a year to ascertain if all cables are adequately protected.

2. Develop a system monitoring and control plan to insure that the system is run optimally.

REHABILITATION

1. Upgrade all anodes to titanium anodes in the next 5 years.

Figure A-1: Layout of Homer Hadley and Lacey V. Murrow Bridges



CONSTRUCTION COST ESTIMATES FOR REHABILITATION RECOMMENDATIONS

1. Upgrade all anodes to titanium anodes in the next 5 years.

Description	Unit	# of Units	Unit Cost	Total Cost				
				Per anode	Homer Hadley		Lacey V. Murrow	
					# of Anodes	Total Cost	# of Anodes	Total Cost
Materials								
Anode	each	1	$325	$325	52	$16,900	56	$18,200
Cable	ft	60	$1	$60	52	$3,120	56	$3,360
Junction Box	each	1	$10	$10	52	$520	56	$560
Splicing Kit	each	1	$25	$25	52	$1,300	56	$1,400
Total Material Cost						**$21,840**		**$23,520**
Labor								
Anode	man hrs	4	$60	$240	52	$12,480	56	$13,440
Junction Box	man hrs	0.5	$60	$30	52	$1,560	56	$1,680
Splicing Kit	man hrs	1	$60	$60	52	$3,120	56	$3,360
Total Labor Cost						**$17,160**		**$18,480**
Mobilization/Demobilization Cost								
Mobilization						$10,000		$10,000
Total Mobilization/Demobilization Cost						**$10,000**		**$10,000**
Contingency on Materials and Labor								
Materials(15%)						$3,276		$3,528
Labor (15%)						$2,574		$2,772
Total Contingency on Mateirals and Labor						**$5,850**		**$6,300**
					Total Cost	**$54,850**		**$58,300**

NOTE

Construction cost estimates provided are for material and labor only. They do not include design engineering costs, traffic control, construction management or administration costs.

APPENDIX A – FIGURES

Figure A-2: Retrieved Anode Coiled for Measurement

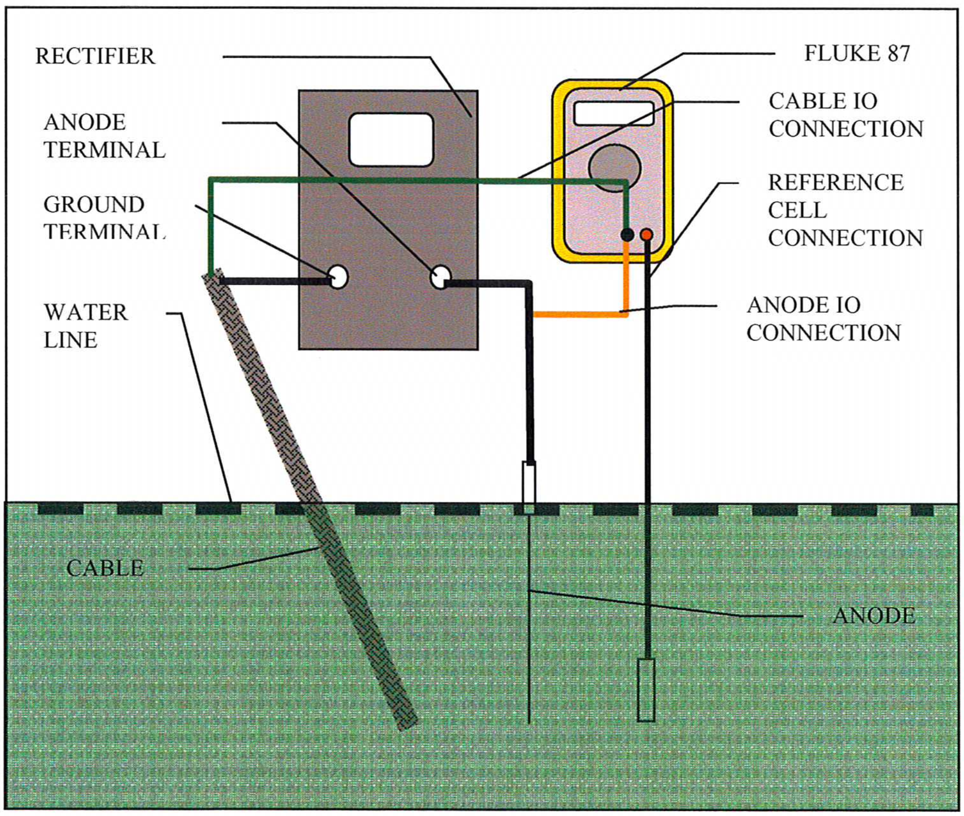


Figure A-3: Reference Cell Connection for Potential Readings

Figure A-4: Typical Coating Damage at the Endcap

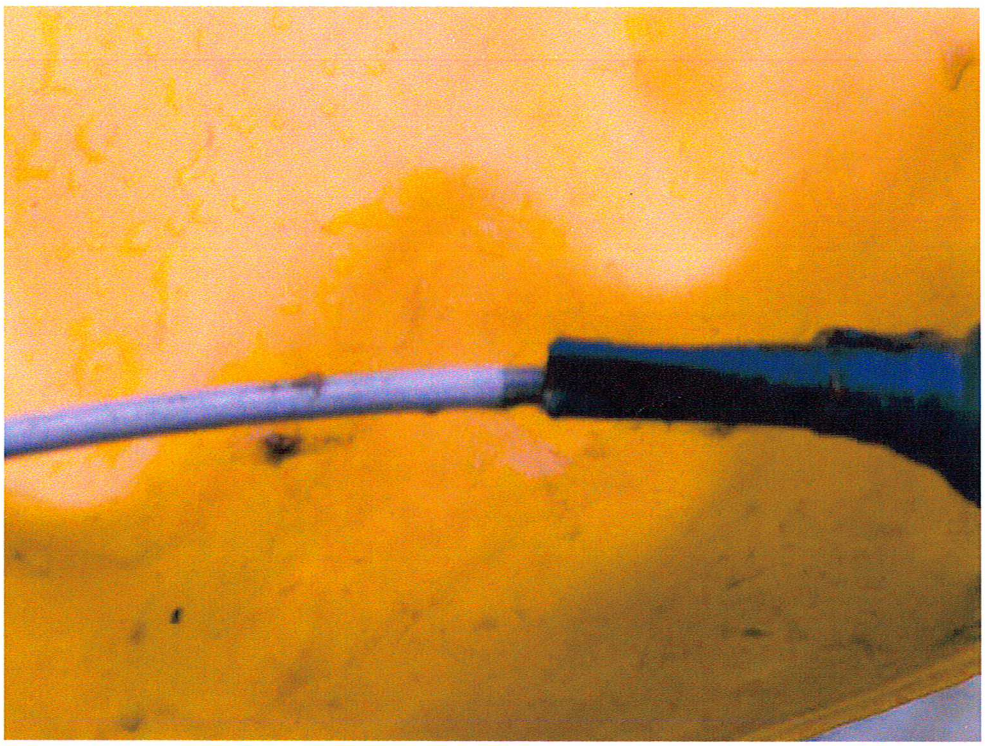


Figure A-5: Crimp Outside the Endcap

APPENDIX B – Tables

TABLE B-1
VISUAL SURVEY RESULTS OF ANODES
HOMER HADLEY

Pontoon	Zone	ANODE			Damage		COMMENTS
		Length (ft.)	Condition	Replacement Needed	TOP	BOT	
A	A1N	50			0.5		
	A1S	54			0.5	0.5	
	A2N	48			0.5	0.5	
	A2S	61			2	0.25	
B	BN			Yes			Anode missing. Two test anode leads found entangled with cable. They were cut off to reduce confusion.
	BS	73			4	1	
C	CN	75		Yes			Anode failed during inspection. It was removed
	CS			Yes			Anode Missing
D	DN	66			0.5	0.5	
	DS			Yes			Anode Missing
E	EN	73			0.5	0.5	
	ES	75			4		
F	FN	80			0.5	4	
	FS	75			3	0.125	
G	GN	78				4	
	GS	75			4	0.5	
H	HN	73				2	
	HS	75		Yes			Anode failed during inspection. It was removed
I	IN	78			0.5	4	
	IS	82			3	0.125	
J	JN	73			2.5	0.5	Endcap damage, water entering encapsulation.
	JS	79			4	0.5	Crimp degradation. Wire kinked at several locations
	JL1N	78			0.5	0.5	Endcap damaged
	JL1S	69			4.5	0.5	
	JL2N	69			0.5		Endcap damaged. Anode was resting on JL3N cable.
	JL2S			Yes			Anode Missing
	JL3N	67			2		
	JL3S	77			3.5	0.5	

TABLE B-1
VISUAL SURVEY RESULTS OF ANODES
HOMER HADLEY

Pontoon	Zone	ANODE			Damage		COMMENTS
		Length (ft.)	Condition	Replacement Needed	TOP	BOT	
J	JL4N	71			2		
	JL4S	77			3.5	0.5	crimp degraded.
	JL5N	68			2		
	JL5S			Yes			Anode Missing
	JL6N	19	Damaged	Yes			Anode failed at 19 ft.
	JL6S			Yes			Anode Missing
K	KN			Yes			Anode Missing
	KS			Yes			Anode Missing
L	LN	76			1		
	LS	77			3.5		
M	MN	59			2.5	0.5	
	MS			Yes			Anode Missing
N	NN			Yes			Anode Missing
	NS			Yes			Anode Missing
O	ON	36			1	0.25	
	OS	32			3		
P	PN	38			2	0.5	
	PS	40			0.5	0.5	
Q	QN			Yes			Anode Missing
	QS	39			2.5	0.5	
R	R1N	42			1	0.5	
	R1S	42					Endcap bottom broken, coating damage
	R2N	41			1	0.5	
	R2S	42					Coating damage at end cap, some copper corrosion products visible

TABLE B-2
VISUAL SURVEY RESULTS OF ANODES
LACEY V. MURROW BRIDGE

Pontoon	Zone	ANODE			Damage		COMMENTS
		Length (ft.)	Condition	Replacement Needed	TOP	BOT	
A	A1N	36		Yes			Kinked during evalaution
	A1S (WEST)	30					
	A1S (EAST)	30					
	A2N (WEST)	34					
	A2N (EAST)	16	Damaged	Yes			Anode broken at 16 ft. Removed
	A2S (WEST)	30					
	A2S (EAST)	20	Damaged	Yes			Anode broken at 20 ft.
B	BN	49					
	BS	42					
C	CN	75					
	CS	42	Damaged	Yes			At the broken end corrosion of copper observable. Copper loss 1".
D	DN	84					
	DS	82			0.5		
E	EN	79					
	ES	62			0.5		
F	FN	75					
	FS	66					
LONGT.	FL1N	80					Coating loss at end of anode.
LONGT.	FL1S	71			1.5		
LONGT.	FL2N	78					
LONGT.	FL2S	65					
LONGT.	FL4N	63					
LONGT.	FL4S	67					Weight and cap missing. Deteriorated encapsulation
LONGT.	FL5N	67					
LONGT.	FL5S	71			0.25		On the pontoon side it is labelled FL4.
G	GN	82					
G	GS	81					
LONGT.	GL3N	70					
LONGT.	GL3S	64					Weight and cap missing. Endcap crimp coating loss.

TABLE B-2
VISUAL SURVEY RESULTS OF ANODES
LACEY V. MURROW BRIDGE

Pontoon	Zone	ANODE			Damage		COMMENTS
		Length (ft.)	Condition	Replacement Needed	TOP	BOT	
LONGT.	GL6N	71					
LONGT.	GL6S	68					
H	HN	79					
	HS	84					
I	IN	84					
	IS	85			0.25		
J	JN	82				0.13	
	JS	6	Damaged	Yes			Copper corrosion product observable at end.
K	KN	68					Weight missing.
	KS	85			0.25		
L	LN	82			0.125		
	LS	94			1		
M	MN	80			0.125	0.125	
	MS	78			0.25	0.25	
N	NN	5					
	NS	29	Damaged	Yes			Failed anode. Significant coating damage and corrosion products.
O	ON	38					
	OS (EAST)	41					
	OS (WEST)	43					
P	PN	42			1		Pt. loss at end of anode
	PS (EAST)	47					
	PS (WEST)	28					
Q	QN	37					
	QS	43			0.5		
R	RN	42					
	RS	50					Slight coating damage at encapsulation.
S	SN	36					
	SS (EAST)	41			0.5		
	SS (WEST)						Anode missing, not hooked to the rectifier. SPARE

TABLE B-2
VISUAL SURVEY RESULTS OF ANODES
LACEY V. MURROW BRIDGE

Pontoon	Zone	ANODE			Damage		COMMENTS
		Length (ft.)	Condition	Replacement Needed	TOP	BOT	
T	T1N (WEST)	38					
	T1N (EAST)	46					
	T1S	94					
	T2N (EAST)	44					Some nicks and scratches.
	T2N (WEST)	19					Broken fishing wire tangled
	T2S	46		Yes			Badly kinked needs replacement

Table B-3: Summary of Depolarization & Polarization Data

Homer Hadley Bridge						
	Depolarization			Polarization		
	300 mV	800 mV	Both	300 mV	800 mV	Both
Total # CP Zones	52	52	52	52	52	52
Total Zones Tested	37	38	37	35	36	35
Total Zones that met Criteria	14	22	14	24	29	24
% Zones that met Criteria	38%	58%	38%	69%	81%	69%

TABLE B-4
CATHODIC PROTECTION SYSTEM DATA
HOMER HADLEY BRIDGE

RECT. #		SYSTEM ON						STATIC		SYSTEM POWER UP			
PONT.	ZONE	RECTIFIER		FLUKE 87		ANODE	CABLE	ANODE	CABLE	FLUKE 87		ANODE	CABLE
		VOLTS	AMPS	VOLTS	AMPS	I/O	I/O			VOLTS	AMPS	I/O	I/O
A	A1N	57	4.5	55.4	4.46	3.6	-0.532	-0.188	-0.488	54.70	4.20	3.60	**-1.008**
	A1S	54	3.5	52.7	4.20	3.6	**-1.124**	-0.230	-0.937	51.50	3.96	4.80	-0.536
	A2N	48	3.7	47.0	3.60	2.4	**-1.000**	0.156	-0.490	46.60	3.53	3.60	**-1.020**
	A2S	56	4.3	54.5	4.29	2.8	**-1.132**	-0.255	-0.928	53.90	4.19	4.40	-0.536
B	BN	SYS OFF								SYS OFF			
	BS	44	4.8	43.6	4.90	2.4	**-0.936**	-0.210	-0.551	43.30	4.90	4.00	-0.652
C	CN	50	5.4	49.2	5.40	2.8	**-1.036**	0.760	-0.430	Anode broke during visual inspection			
	CS	Rectifier on, anode missing								SYS OFF			
D	DN	52	5.5	52.9	5.80	2.8	**-0.964**	-0.114	-0.635	52.40	5.80	3.60	**-1.000**
	DS	SYS OFF								SYS OFF			
E	EN	42	4.2	42.7	4.60	2.4	**-0.920**	-0.070	-0.490	42.20	4.60	1.80	**-0.880**
	ES	40	4.0	38.8	4.20	1.7	**-0.832**	0.050	-0.488	38.42	4.00	1.80	**-0.880**
F	FN	42	4.1	41.6	4.40	1.88	-0.720	SYSTEM ON		40.90	4.40	1.80	**-0.960**
	FS	38	3.7	36.8	3.80	1.88	-0.724	0.166	-0.696	36.17	3.80	1.80	**-0.920**
G	GN	24	2.3	23.7	2.40	1.4	**-1.052**	-0.064	-0.745	23.50	2.40	1.56	**-1.040**
	GS	38	4.2	41.8	4.40	3.6	**-1.228**	-0.112	-0.817	41.40	4.40	1.72	**-1.200**
H	HN	24	2.4	25.1	2.40	1.84	-0.748	0.060	-0.570	24.27	2.60	1.64	**-1.040**
	HS	39	3.0	39.8	4.20	2.04	-0.556	-0.513	-0.526	Anode broke during visual inspection			
I	IN	34	3.4	33.3	2.40	1.76	**-0.940**	-0.030	-0.696	32.45	3.40	1.80	**-1.080**
	IS	34	3.4	33..6	3.60	1.76	**-0.844**	-0.038	-0.669	32.70	3.60	-0.08	**-0.952**
J	JN	40	4.0	41.5	4.00	1.92	-0.668	0.125	-0.403	41.00	4.00	1.76	**-0.920**
	JS	32	3.0	30.0	2.80	1.84	-0.624	0.135	-0.412	29.43	2.80	1.64	**-0.920**
	JL1N	44	3.8	46.2	4.80	2.8	-0.360	0.165	-0.431	46.30	4.60	2.04	-0.520
	JL1S	40	2.6	39.7	4.20	2.08	-0.572	0.172	-0.400	38.68	4.00	1.88	**-0.840**
	JL2N	40	3.9	40.1	3.40	2.08	-0.628	0.167	-0.426	39.81	3.60	1.84	**-0.880**
	JL2S	Rectifier on, anode missing								SYS OFF			
	JL3N	23	0.8	24.7	2.00	1.72	**-0.912**	0.167	-0.655	24.80	2.00	1.60	**-1.160**
	JL3S	40	3.2	39.3	4.20	2.04	-0.584	0.133	-0.399	38.53	4.00	1.88	**-0.840**

TABLE B-4
CATHODIC PROTECTION SYSTEM DATA
HOMER HADLEY BRIDGE

RECT. #		SYSTEM ON						STATIC		SYSTEM POWER UP			
PONT.	ZONE	RECTIFIER		FLUKE 87		ANODE	CABLE	ANODE	CABLE	FLUKE 87		ANODE	CABLE
		VOLTS	AMPS	VOLTS	AMPS	I/O	I/O			VOLTS	AMPS	I/O	I/O
J	JL4N	30	3.0	31.0	3.00	1.84	**-0.972**	0.136	-0.750	30.65	2.60	1.44	**-1.640**
	JL4S	38	3.8	37.1	NA	2	-0.264	0.165	-0.499	36.41	3.80	0.88	**-1.720**
	JL5N	35	3.1	33.4	2.40	1.88	**-0.972**	0.135	-0.795	32.77	3.40	1.60	**-1.440**
	JL5S	SYS OFF								SYS OFF			
	JL6N	SYS OFF								SYS OFF			
	JL6S	SYS OFF								SYS OFF			
K	KN	SYS OFF								SYS OFF			
	KS	SYS OFF								SYS OFF			
L	LN	19	1.9	17.8	4.50	1.096	-0.568	-0.053	-0.491	17.50	1.69	1.56	-0.684
	LS	38	3.9	35.7	4.00	1.412	**-0.876**	-0.021	-0.486	35.27	4.10	1.84	-0.672
M	MN	41	2.9	42.0	3.80	1.140	-0.708	-0.016	-0.603	41.60	4.00	1.72	**-1.000**
	MS	SYS OFF								SYS OFF			
N	NN	SYS OFF								SYS OFF			
	NS	SYS OFF								SYS OFF			
O	ON	30	1.5	28.0	1.50	1.8	**-1.048**	-0.014	-0.590	27.90	1.50	1.68	**-1.320**
	OS	24	1.4	24.0	1.20	1.7	**-1.144**	-0.012	-0.801	23.88	1.20	1.52	**-1.440**
P	PN	42	2.2	41.8	2.50	1.920	**-1.212**	0.023	-0.648	41.90	2.60	1.88	**-1.440**
	PS	32	1.9	31.1	1.90	1.84	-0.748	-0.023	-0.648	31.50	1.99	1.76	**-0.880**
Q	QN	SYS OFF								SYS OFF			
	QS	44	2.9	43.0	2.88	2.8	-0.752	0.012	-0.474	43.20	2.87	4.00	-0.556
R	R1N	40	2.4	37.6	2.30		**-1.021**	-0.005	-0.697	37.60	2.40	1.48	**-1.200**
	R1S	56	1.6	52.5	33.00	4	**-0.992**	-0.043	-0.785	51.60	3.34	4.00	**-1.116**
	R2N	42	2.4	41.2	28.80		**-1.940**	-0.002	-1.032	40.90	2.40	1.44	**-2.084**
	R2S	SYS OFF								SYS OFF			

NOTES: Green color signigfies that the particular criterion was met.

TABLE B-5
DEPOLARIZATION/POLARIZATION DATA
HOMER HADLEY BRIDGE

RECT. #		DEPOLARIZATION		POLARIZATION	
PONT.	ZONE	ANODE	CABLE	ANODE	CABLE
A	A1N	-3.788	0.044	3.788	-0.520
	A1S	-3.830	0.187	5.030	0.401
	A2N	-2.244	0.510	3.444	-0.530
	A2S	-3.055	0.204	4.655	0.392
B	BN				
	BS	-2.610	0.385	4.210	-0.101
C	CN	-2.040	0.606		
	CS				
D	DN	-2.914	0.329	3.714	-0.365
	DS				
E	EN	-2.470	0.430	1.870	-0.390
	ES	-1.650	0.344	1.750	-0.392
F	FN				
	FS	-1.714	0.028	1.634	-0.224
G	GN	-1.464	0.307	1.624	-0.295
	GS	-3.712	0.411	1.832	-0.383
H	HN	-1.780	0.178	1.580	-0.470
	HS	-2.553	0.030		
I	IN	-1.790	0.244	1.830	-0.384
	IS	-1.798	0.175	-0.042	-0.283
J	JN	-1.795	0.265	1.635	-0.517
	JS	-1.705	0.212	1.505	-0.508
	JL1N	-2.635	-0.071	1.875	-0.089
	JL1S	-1.908	0.172	1.708	-0.440
	JL2N	-1.913	0.202	1.673	-0.454
	JL2S				
	JL3N	-1.553	0.257	1.433	-0.505
	JL3S	-1.907	0.185	1.747	-0.441

TABLE B-5
DEPOLARIZATION/POLARIZATION DATA
HOMER HADLEY BRIDGE

RECT. #		DEPOLARIZATION		POLARIZATION	
PONT.	ZONE	ANODE	CABLE	ANODE	CABLE
J	JL4N	-1.704	0.222	1.304	-0.890
	JL4S	-1.835	-0.235	0.715	-1.221
	JL5N	-1.745	0.177	1.465	-0.645
	JL5S				
	JL6N				
	JL6S				
K	KN				
	KS				
L	LN	-1.149	0.077	1.613	-0.193
	LS	-1.433	0.390	1.861	-0.186
M	MN	-1.156	0.105	1.736	-0.397
	MS				
N	NN				
	NS				
O	ON	-1.814	0.458	1.694	-0.730
	OS	-1.712	0.343	1.532	-0.639
P	PN	-1.897	0.564	1.857	-0.792
	PS	-1.863	0.100	1.783	-0.232
Q	QN				
	QS	-2.788	0.278	3.988	-0.082
R	R1N		0.324	1.485	-0.503
	R1S	-4.043	0.207	4.043	-0.331
	R2N		0.908	1.442	-1.052
	R2S				

NOTES: Green color signigfies that the particular criterion was met.

Table B-6: Summary of Depolarization & Polarization Data

Lacey V. Murrow Bridge						
	Depolarization			Polarization		
	300 mV	800 mV	Both	300 mV	800 mV	Both
Total # CP Zones	**56**	**56**	**56**	**56**	**56**	**56**
Total Zones Tested	48	51	48	47	50	47
Total Zones that met Criteria	2	42	5	1	44	1
% Zones that met Criteria	4%	82%	10%	2%	88%	2%

TABLE B-7
CATHODIC PROTECTION SYSTEM DATA
LACEY V. MURROW

RECT. #		SYSTEM ON						STATIC		SYSTEM POWER UP			
PONT.	ZONE	RECTIFIER		FLUKE 87		ANODE	CABLE	ANODE	CABLE	FLUKE 87		ANODE	CABLE
		VOLTS	AMPS	VOLTS	AMPS	I/O	I/O			VOLTS	AMPS	I/O	I/O
A	A1N	16	0.6	15.92	0.75	1.84	-0.660	-0.104	-0.818	16.13	0.71	1.52	-1.016
	A1S	6	0.4	6.92	0.40	1.48	-0.928	-0.004	-0.766	6.94	0.36	1.40	-0.968
	A2N	16	1	16.27	0.98	1.68	-0.724	-0.103	-0.818	16.76	0.75	1.52	-1.020
	A2S	SYS OFF	One anode was good. System turned on					0.211	-0.767	11.61	0.50	1.52	-0.964
B	BN	12	0.6	11.80	0.70	1.56	-0.964	-0.008	-0.871	12.06	0.60	1.68	-1.056
	BS	13	0.6	11.10	0.60	1.56	-1.004	0.036	-0.871	11.24	0.56	1.60	-1.044
C	CN	6	0.5	6.88	0.54	1.56	-0.696	0.023	-0.678	6.98	0.50	1.56	-0.780
	CS	SYS OFF							-0.647	SYS OFF			
D	DN	12	1	12.84	1.20	1.44	-1.032	-0.076	-0.903	12.89	1.14	1.55	-1.056
	DS	36	3.6	37.42	3.78	1.68	-1.028	-0.109	-0.899	37.44	3.78	1.60	-1.028
E	EN	8	0.6	8.14	0.64	1.44	-1.096	0.113	-0.964	8.26	0.58	1.48	-1.084
	ES	34	3.5	36.48	3.71	1.8	-0.936	-0.001	-0.800	36.44	3.71	1.76	-0.948
F	FN	12	0.8	12.86	0.90	1.44	-1.056	-0.099	-0.926	13.01	0.84	1.40	-1.116
	FS	18	0.7	17.43	1.26	1.52	-1.064	-0.015	-0.927	17.42	1.26	1.48	-1.120
	FL1N	28	2.7	27.19	2.84	1.68	-1.028	-0.103	-0.933	27.46	2.80	1.72	-1.128
	FL1S	28	3	29.01	2.76	1.64	-1.020	-0.012	-0.927	28.75	2.62	1.64	-1.124
	FL2N	12	1	12.81	1.04	1.48	-1.172	-0.1	-1.128	12.96	1.00	1.48	-1.224
	FL2S	17	1.2	18.09	1.53	1.52	-1.048	-0.028	-0.939	18.23	1.42	1.52	-1.148
	FL4N	12	1.6	13.62	1.14	1.52	-1.028	-0.118	-0.973	14.01	0.94	1.48	-1.188
	FL4S	31	3.4	32.31	3.14	1.68	-1.016	-0.065	-0.927	32.41	2.98	1.64	-1.124
	FL5N	10	1.2	13.55	1.06	1.52	-1.052	-0.037	-0.974	13.16	0.92	1.48	-1.224
	FL5S	20	2.2	23.03	2.02	1.6	-1.028	-0.036	-0.927	22.98	1.98	1.52	-1.128
G	GN	8	0.4	7.80	0.54	1.44	-1.016	-0.061	-0.931	7.95	0.48	1.40	-1.040
	GS	12	1	12.82	1.04	1.44	-1.020	0.014	-0.966	12.85	1.06	1.52	-1.008
	GL3N	12	1.5	15.45	1.20	1.44	-1.132	SYSTEM ON		15.49	1.22	1.56	-0.960
	GL3S	30	3.2	31.09	3.02	1.64	-1.004	-0.022	-0.931	31.16	2.94	1.68	-1.036
	GL6N	18	0.2	18.13	1.52	1.48	-1.236	-0.09	-1.146	SYS OFF			
	GL6S	12	0.9	12.75	0.96	1.48	-1.152	-0.018	-1.015	12.80	0.98	1.44	-1.096
H	HN	8	0.6	8.49	0.68	1.52	-0.844	SYSTEM ON		8.52	0.64	1.40	-0.860
	HS	12	1	13.50	1.18	1.52	-0.864	0.156	-0.873	13.50	1.80	1.48	-0.868

TABLE B-7
CATHODIC PROTECTION SYSTEM DATA
LACEY V. MURROW

RECT. #		SYSTEM ON						STATIC		SYSTEM POWER UP			
PONT.	ZONE	RECTIFIER		FLUKE 87		ANODE	CABLE	ANODE	CABLE	FLUKE 87		ANODE	CABLE
		VOLTS	AMPS	VOLTS	AMPS	I/O	I/O			VOLTS	AMPS	I/O	I/O
I	IN	17	1.6	18.11	1.80	1.6	-0.948	0.065	-0.834	18.14	1.68	1.60	-0.948
	IS	26	2.7	26.47	2.60	1.76	-0.952	0.093	-0.835	26.55	2.64	1.84	-0.936
J	JN	20	2	22.81	2.20	1.64	-0.856	0.037	-0.776	22.97	2.12	1.56	-0.972
	JS	SYS OFF						0.064	-0.822	SYS OFF			
K	KN	8	0.6	8.12	0.60	1.52	-0.916	-0.076	-0.825	8.23	0.56	1.44	-0.968
	KS	28	2.6	27.65	2.80	1.64	-0.912	-0.021	-0.824	27.72	2.78	1.48	-0.962
L	LN	36	0.9	18.50	1.80	1.64	-0.828	-0.052	-0.752	18.51	1.80	1.56	-0.788
	LS	2	0.2	NA	0.20	-0.492	-1.516		-0.726	SYS OFF			
M	MN	25	2.5	24.60	2.50	1.72	-0.948	-0.052	-0.823	24.74	2.42	1.56	-0.972
	MS	29	2.9	29.60	3.00	1.84	-0.948	0.07	-0.835	29.63	3.00	1.80	-0.960
N	NN	6	0.5	6.90	0.50	1.6	-0.656	0.135	-0.579	6.93	0.53	1.52	-0.684
	NS	SYS OFF						0.209	-0.579	SYS OFF			
O	ON	6	0.4	6.90	0.30	1.64	-0.860	-0.023	-0.857	6.95	0.27	1.52	-1.084
	OS	16	1.6	16.00	1.60	1.8	-0.752	0.064	-0.634	15.82	1.60	1.62	-0.732
P	PN	20	1.4	21.20	1.30	1.7	-0.848	-0.081	-0.748	21.02	1.38	1.60	-0.916
	PS	6	0.4	7.10	0.40	1.4	-1.036	-0.049	-0.935	7.05	0.45	1.36	-1.172
Q	QN	6	0.3	7.20	0.30	1.6	-0.884	SYSTEM ON		7.13	0.32	1.48	-0.992
	QS	18	1.1	20.40	1.20	1.8	-0.776	0.031	-0.657	20.18	1.23	1.64	-0.812
R	RN	6	0.4	7.40	0.30	1.72	-0.720	-0.187	-0.561	7.36	0.34	1.64	-0.724
	RS	19	1.4	20.50	1.30	1.92	-0.720	-0.208	-0.558	20.39	1.30	1.88	-0.712
S	SN	7	0.5	7.00	0.30	1.4	-1.044	-0.062	-0.966	7.08	0.30	1.28	-1.188
	SS	20	1.4	20.30	1.20	1.6	-0.996	-0.037	-0.754	20.44	1.31	1.52	-0.972
T	T1N	14	1	16.00	1.10	1.64	-1.256	-0.032	-0.951	16.00	1.20	1.60	-1.292
	T1S	6	0.2	6.90	0.30	1.72	-0.788	-0.045	-0.889	6.90	0.30	1.48	-1.036
	T2N	SYS OFF						-0.149	-0.927	SYS OFF			
	T2S	6	0.2	7.00	0.30	1.76	-0.800	-0.015	-0.886	7.08	0.28	1.52	-1.000

NOTES: Green color signigfies that the particular criterion was met.

TABLE B-8
DEPOLARIZATION/POLARIZATION DATA
LACEY V. MURROW

RECT. #		DEPOLARIZATION		POLARIZATION	
PONT.	ZONE	ANODE	CABLE	ANODE	CABLE
A	A1N	-1.944	-0.158	1.624	-0.198
	A1S	-1.484	0.162	1.404	-0.202
	A2N	-1.783	-0.094	1.623	-0.202
	A2S			1.309	-0.197
B	BN	-1.568	0.093	1.688	-0.185
	BS	-1.524	0.133	1.564	-0.173
C	CN	-1.537	0.018	1.537	-0.102
	CS				
D	DN	-1.516	0.129	1.626	-0.153
	DS	-1.789	0.129	1.709	-0.129
E	EN	-1.327	0.132	1.367	-0.120
	ES	-1.801	0.136	1.761	-0.148
F	FN	-1.539	0.130	1.499	-0.190
	FS	-1.535	0.137	1.495	-0.193
	FL1N	-1.783	0.095	1.823	-0.195
	FL1S	-1.652	0.093	1.652	-0.197
	FL2N	-1.580	0.044	1.580	-0.096
	FL2S	-1.548	0.109	1.548	-0.209
	FL4N	-1.638	0.055	1.598	-0.215
	FL4S	-1.745	0.089	1.705	-0.197
	FL5N	-1.557	0.078	1.517	-0.250
	FL5S	-1.636	0.101	1.556	-0.201
G	GN	-1.501	0.085	1.461	-0.109
	GS	-1.426	0.054	1.506	-0.042
	GL3N				
	GL3S	-1.662	0.073	1.702	-0.105
	GL6N	-1.570	0.090		
	GL6S	-1.498	0.137	1.458	-0.081
H	HN				
	HS	-1.364	-0.009	1.324	0.005

TABLE B-8
DEPOLARIZATION/POLARIZATION DATA
LACEY V. MURROW

RECT. #		DEPOLARIZATION		POLARIZATION	
PONT.	ZONE	ANODE	CABLE	ANODE	CABLE
I	IN	-1.535	0.114	1.535	-0.114
	IS	-1.667	0.117	1.747	-0.101
J	JN	-1.603	0.080	1.523	-0.196
	JS				
K	KN	-1.596	0.091	1.516	-0.143
	KS	-1.661	0.088	1.501	-0.138
L	LN	-1.692	0.076	1.612	-0.036
	LS		**0.790**		
M	MN	-1.772	0.125	1.612	-0.149
	MS	-1.770	0.113	1.730	-0.125
N	NN	-1.465	0.077	1.385	-0.105
	NS				
O	ON	-1.663	0.003	1.543	-0.227
	OS	-1.736	0.118	1.556	-0.098
P	PN	-1.781	0.100	1.681	-0.168
	PS	-1.449	0.101	1.409	-0.237
Q	QN				
	QS	-1.769	0.119	1.609	-0.155
R	RN	-1.907	0.159	1.827	-0.163
	RS	-2.128	0.162	2.088	-0.154
S	SN	-1.462	0.078	1.342	-0.222
	SS	-1.637	0.242	1.557	-0.218
T	T1N	-1.672	**0.305**	1.632	**-0.341**
	T1S	-1.765	-0.101	1.525	-0.147
	T2N				
	T2S	-1.775	-0.086	1.535	-0.114

NOTES: Green color signigfies that the particular criterion was met.

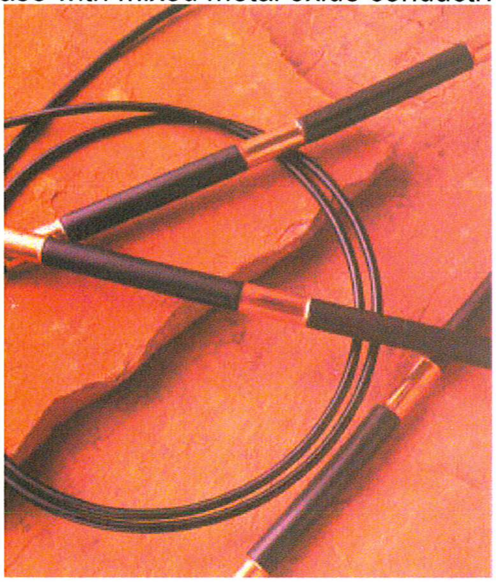
APPENDIX C – REPLACEMENT TITANIUM ANODE DESIGN

REPLACEMENT TITANIUM ANODE DESIGN
Lacey V. Murrow and Homer Hadley Bridges

ANODE

Anode: LIDA Tubular Anode (or Alternate US Filter)
Titanium base with mixed metal oxide conductive coating

Anode #:	2.5/100
Anode Length:	100 cm
Anode Diameter:	2.5 cm
Anode Weight:	0.77 lbs
Anode Surface Area:	0.84 ft^2
# of Tails:	1
# of Anodes in a String:	1
Max Current Rating above 40˚F	13.5 A
Max Current Rating below 40˚F	9.5 A



CABLE

Insulation: Helar/HMWPE (chlorine resistant)
Wire Size: #8
Cable Length: 60 ft.

CABLE/ANODE CONNECTION

Crimp: LIDA Crimp (factory installed)
Weight attached to end of anode: 5 lbs.

Notes: Anode shall be supplied ready for installation
Length of the cable can be varied
Either the top of the anode shall be placed below the bottom of the pontoon or the center of the anode shall be placed 10 feet below the low mean water line, whichever is deeper.
The free end of the cable shall be spliced to the existing cable in a junction box located inside the pontoon and sealed against moisture ingress.
A 5 lbs weight shall be attached to the end of the anode. It shall be factory installed using LIDA crimp

APPENDIX D – Scope of Work

Scope of Work
In Depth Inspection of the Cathodic Protection Systems on
Lacey V Murrow Bridge (90/25S and
Homer Hadley Bridge (90/25N)

I. Inspection

The inspection shall be performed by a NACE Certified Corrosion Specialist/ Cathodic Protection Specialist. Access to the two bridges will be provided by WSDOT. The working hours for the maintenance crew is 5:30 AM to 3:00 PM and the inspection shall be performed during these hours. The bridge is equipped with access and work area lighting and 120-volt receptacles are available in the vicinity of each CP rectifier.

- Survey the electrical operating parameters of the cathodic protection systems for the two bridges.
- Survey the condition of the anodes
- Survey the condition of the concrete floating pontoons from a corrosion point of view.
- Provide a written report documenting the results of the survey and the analysis of the results. The written report shall consist of both written and photographic documentation of field conditions. Based on the results of the inspection and analysis of the data collected recommendations shall be provided for maintenance and rehabilitation with cost estimates for rehabilitation items.
- At the completion of the inspection a training class will be held for WSDOT maintenance and Engineering personnel on how to monitor and calibrate the cathodic protection system.

II. Deliverables

Deliverables will consist of 2 draft copies for review and a bound original and 6 bound copies of the final report. The final report shall be stamped and signed by an engineer licensed in the State of Washington and signed by an NACE certified Corrosion Specialist/Cathodic Protection Specialist.

- The report will contain all field observations, measurements, maintenance and rehabilitation recommendations, cost estimates for any rehabilitation recommendations, color photographs and other supporting documentation.
- Deficiencies will be ranked.
- Recommendations will be made for maintenance and rehabilitation items.
- Cost estimates will be included for all rehabilitation items.